DESIGNING FOR HUMANS NOT ROBOTS (OR VULCANS)[1]

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Abstract
There is growing interest in embodiment in information seeking which we use as an opportunity to reconsider what we as designers of information interfaces aim for. While we have become quite good at developing interfaces that are effective at supporting specific needs or needs that have been rendered specific we are still not good at proving interfaces that reflect a key human characteristic and strength which is being embedded in this world and being curious about it. While this discussion is related to research into serendipity (c.f. Erdelez et al 2016) we stay clear of this body of work since we feel the issue is a broader one: we seem to have got stuck designing interfaces that are more suitable for patient, logical, rational robots (or Vulcans) than for mammals who get tired, bored, exited, irritated, intrigued or distracted, and who even change their minds about what they want to do.

Introduction

As information science researchers we appear to be dealing with a digital vs. analogue dichotomy that we (along with a growing number of other scholars) argue is artificially construed. All our interactions are necessarily embodied, including interactions with digital information. This means we break with a long tradition of seeing information seeking as an activity that is largely cognitive in nature with hands, eyes and ears merely serving to communicate with the computer system. The reason for breaking with this tradition is that decades of research into embodied cognition suggest that *having a body* plays a fundamental role in enabling human-level intelligent behavior: the way the physical body interacts with the world helps re-structure and simplify activities including collecting and processing low-level sensory information (Pfeifer and Bongard 2009). This is a point we will return to when discussing Clark's (1997) scaffolding minds perspective.

There is growing interest in embodiment in information seeking. Similar to other disciplines including cognitive science itself, 'embodiment' is more of an umbrella term denoting a general direction rather than a specific school of thought or even definition. Cox et al. (2017) and Olsson & Lloyd (2016) provide good overviews of this work as well as particular analyses from their own scholarship. This interest can inspire a realignment of what we want to improve as designers of interfaces supporting information access. Interfaces, in the context of this paper, range from traditional desktop computer displays to tablets and smartphones, to novel interfaces such as mixed reality approaches to information display and access. Whatever their physical instantiation, such interfaces have in common that their designs embed certain assumptions about their users (explicit or too often implicit), use contexts, and

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the nature of their users' assumed information needs. Crucially, we are not brains floating in tanks with Ethernet connections aka the brain in the vat, and we should not design our systems as if that were the case.

Conceptualizing information seeking the traditional way as a largely cognitive activity resembles the way 'problem solving' was conceptualized in classical AI (Lueg 2002). The image of a 'brain in the vat' (actually a thought experiment) is a popular depiction of the corresponding school of thought. Trying to abstract information seeking away from the corporeality of a person being embodied in the world introduced problems similar to those faced by "general problem solvers" explored in early AI research - especially loss of context. This matters because human "problem solvers" have evolved to utilize the world in creative ways as a rich resource that can help deal with "problems" (Lueg and Pfeifer 1997).

In this paper we explore the idea that physicality and embodiment can have effects that both support and inhibit information seeking processes. We compare the different processes of information seeking while walking round a physical library, bookshop, museum, office or marketplace to how one does information seeking with say a networked laptop.

van House, in her analysis of potential intersections between Science and Technology Studies (STS) and Information Studies touches on many of the same issues. She notes how "Science as practice emphasizes the actual, messy work of science" and that STS researchers highlight "the role of embodied skills, as opposed to the sanitized reports of science as an intellectual, cognitive activity". There are similar temptations to report information seeking as an intellectual, cognitive activity, and hide away some of the actual messy work of information seeking. van House (2004) also notes how certain STS approaches, most notably activity theory and symbolic interactionism "both reject the common dichotomies between micro and macro, mental and material, and observation and intervention in analysis and redesign of work."

In information seeking it doesn't make sense either to draw binary distinctions between the digital and physical worlds. One can be using a smartphone to look for information while walking around – and one's physical setting will impact digital information seeking, just as will the design of the information seeking interface and functionality. We also keep in mind that real world information seeking processes can be likened to berry picking (Bates 1989) in the sense that bits of relevant information are 'picked' from different virtual or real locations, and over a period of time. While this is often mediated by computer interfaces it may also include using information that is available in the environment. In her ISIC keynote Bates (2002) described this saying that

> *"[...] intentionally or unintentionally, we often arrange our physical and social environment so as to provide the information we need when we need it. From grocery lists to the arrangement of dials in airplane cockpits, to the physical placement of and organization of tools and offices, we make it possible to be reminded, when we need reminding, of next steps or appropriate behaviors."*

These observations are compatible with Clark's (1997) scaffolding minds perspective on human cognition which postulates that human intelligent behaviour is to a large extent dependent on structuring and exploiting the physical and also the social environment. The scaffolding minds perspective is informed by the observation that the human mind is not particularly strong at complex information-processing tasks (e.g., doing calculations in their heads) however it is very strong at reasoning by association. Accordingly, the scaffolding minds perspective sees the ability to transform complex “information-processing tasks” into simpler associative tasks by exploiting structures of the real world and by actively re-structuring problems into series of simpler problems that are better suited to specific characteristics of human cognition as key to human level intelligent behavior. Documents, from that perspective, demonstrate the capability to "outsource" information to the physical environment and physical reminders such as letters placed by the door demonstrate how "remembering to post a letter", primarily a cognitive activity, can be transformed into an embodied association activity where the transformed physical environment 'embodies' the task. Bates’ point also chimes with work on distributed cognition (Hutchins 1995) where people can partially or completely offload cognitively demanding activities into the world by moving things around.

How do computer interfaces fit into the picture? Computers are tools that can be used to solve problems but they aren't problem solvers themselves (von Foerster 1970, quoted in Lueg 2002). Computer interfaces connect a computer – underlying algorithms, databases and hardware – to us – a human body containing a physical brain, but via our senses. The interface itself interacts in complex psychophysiological ways with our eyes, ears, fingers, kinaesthetic sense, and physical setting. In a way, an interface plays the role of a mediator but without possessing the corporeal experience and knowledge of an actual (human) mediator. As information scientists we are of course very aware of the powerful role that human mediators can play, as expressed beautifully by Nardi and O'Day (1999, p. 85):

> *"One of the most valuable (and unheralded) services librarians provide is to help clients understand their own needs—a kind of information therapy. Interacting with a reference librarian can be very much like going to a good psychotherapist who, through skillful questioning, gets you to talk about what's really bothering you."*

In what follows we argue that as designers of information interfaces we need to find ways to take into account the nature of the very different environments in which information needs manifest, as the characteristics can either limit or enhance, sometimes concurrently, the nature of the information seeking process.

DIGITAL VS ANALOGUE DICHOTOMY

We can be inclined to think of the process of digitization as about transforming a physical representation of information (say ink on paper) into a purely virtual form of software; conveniently ignoring the hardware and accompanying infrastructure within which reside the data structures encoding the digitized text. The process of digitization can be seen as ‘freeing’ the information from its hardware manifestation to exist as pure software. Admittedly in the process certain aesthetics of the traditional information gathering experience are lost, which is why we may at times prefer the heft, smell and patina of old books. But we can be inclined to regard these as separate

from the ‘pure’ information contained in the book and now liberated as bit sequences to be searched more quickly and efficiently and manifested in multiple different interfaces.

Indeed at times it can feel that as computer scientists working on digitization, information retrieval and digital libraries, we have an almost Aristotelian framework, caring about the ‘substance’ of the text to be digitized (the software) and treating everything else as ‘accidents’ (the ‘hardware’ manifesting the text).

From the perspective of information scarcity, digitization is a great boon. A small library of a few thousand physical books can be supplemented by access to a digital library of tens of millions of books. From this perspective, digitization and disembodiment of the book can be seen as a way to address problems of scarcity. Digitization also offers new ways of publishing. This goes beyond the scope of the paper but we want to mention nevertheless the case of Proust's *Swann's Way*. As Norton (2013) describes it

> *"As it happens, I'm reading Swann's Way on a Kindle – which is more appropriate than you might think. The novel was effectively self-published by Proust himself (he paid a publisher to put it out) because the manuscript had been turned down by umpteen respectable publishing houses. If he had written it today, he could have published it himself, at no expense, as a Kindle book, just like EL James, the author of Fifty Shades of Grey, did in more recent times."*

However, fixing one problem tends to cause or reveal other problems. The physicality of the book is lost if all one has access to is a digital version. This can lead to interest in providing alternative ways of interacting with digital books, sometimes directly replicating aspects of the physical book like dog ears or read wear (e.g., Hill et al 1992), and sometimes drawing on them for metaphorical rather than literal inspiration. Page turning and book marking are examples (Chu et al 2003). This is not just a nostalgic rejection of the new. Many things are now possible with digital books that were impossible such as in-text search or were merely really difficult or expensive with physical books e.g., the case of rare books or deteriorating government records that require climate-controlled storage.

Cox et al. (2017) remind us that reading itself is an embodied activity

> *“Studies of reading on new types of devices such as Kindles and iPads reveal that changing the technologies of books reshapes reading, and in doing so reveal the extent to which reading is always an embodied experience. At the most obvious level we use the eyes to read the text. But books engage our other senses. The material qualities of printed books, their feel, even smell, are often cited as a reason to prefer them to digital versions.*

One can read the same text while holding a rare first edition, a leather bound collector’s item, a tatty paperback bought in a used bookshop, a laptop, a mouse, an iPad or a smartphone. To use FRBR definitions, all can be the same expression, but the different manifestations can lead to somewhat different physical and bodily experiences.

Both digitization and digital access to physical books (such as contrasting Amazon with a large physical bookstore) offer many advantages. Search of digitized resources

typically becomes much easier, including full content search in addition to metadata search. Huge analyses over giant corpora of literature such as the Hathi Trust dataset (www.hathitrust.org) become possible. However browsing seems to be intrinsically different and arguably more difficult (e.g., Jabr 2013). Amazon and other online stores had to put considerable effort into supporting browsing and serendipitous discovery – features that sometimes appear almost for free in 'real world' settings of browsing a physical bookstore, even a market stall of used books. By examining the various different ways that browsing and serendipity are afforded in the physical world we can learn to appreciate it, to design to support multiple alternate ways in physical settings and draw inspiration for better support in digital settings.

Existing information retrieval systems do an outstanding job at supporting known item search. Perhaps not coincidentally this seems to be a use scenario where considering embodiment appears to have the least to contribute. By contrast, other use scenarios, as experienced in real world settings often draw upon that setting as a resource. Examples include various kinds of browsing aiming to answer questions and statements such as:

- "What have you got?"
- "I don't know what I want but I'll know it when I see it"
- "What should I be trying to find out?"
- "What matters?"
- "What is interesting?"
- "What is everyone else doing?"
- "What's the first thing I need to do?"
- "What have I forgotten?"
- "What should my information need be, really?"
- "Surprise and delight me!"

DIGITIZATION AND EMBODIMENT

It is hardly surprising that we are tempted to ignore the body. After all, the design of computerized information retrieval systems has involved the extraction of information that has traditional resided in recognizably material forms such as ink on paper. As a result of this digitization perspective it is perhaps understandable that we think of information retrieval as an activity that resides in software that links via an interface to a somewhat disembodied brain. Consequently it is important to keep reminding ourselves that we are designing information structures for humans who are indeed embodied. We are not designing for a consciousness that exists virtually within out interconnected computer networks, nor for a robot that connects to that network.

How is browsing afforded by being embodied in the real world? Lueg (2014) highlights some of the psycho-physiological aspects of this. Recall being in the library stacks or an actual bookstore. Most computer interfaces present a boxed, flat view on information (more precisely: representations thereof) which does not normally change until requested by the user. By contrast the real world affords a three-dimensional view that changes frequently in response to body, head, and eye movements. This is the case even when those movements are subtle or occurring while doing something else, such as glancing at someone walking past or checking the phone. Human

perception is a continuous process that does not stop when moving visual attention from items on a bookshelf to the phone in one's hand, thereby triggering additional, possibly subconscious noticing of information present in the environment. Along with the human 120 degree vision field (which still is fairly narrow field compared to insects with large compound eyes, like cockroaches and dragonflies, that have a wide field of view of 360 degrees) this is fundamentally different to engaging with an interface 'window' on information where explicit switching between discreet documents or search results is required. From that point of view 'browsing' on such a screen remains a poor imitation of the real world browsing experience. Reality is profligate, partial and wasteful, but continually surprising. Virtuality by contrast can render access to some information much faster and more cheaply by low cost copying and providing myriad additional connections.

Other effects of being in the real world include changing light conditions as light and shade may emphasise or de-emphasise information without one's input. In fact there is a whole range of environmental conditions impacting on perception that are leveraged in marketing (c.f., Underhill 1999) while largely under-recognized and under-explored in information behavior research. For example, our sense of smell is exploited as a way of triggering feelings of comfort and/or reminiscence when grocery stores bake some of their bread in-store therefore spreading the smell of freshly baked bread. Specific light is used to over-emphasise the natural colour of fruit and vegetables making them look more attractive in their customers's eyes. Different floor coverings are used to allow customers to speed up (hard surfaces) or make them slow down and feel more comfortable (soft carpet).

The advantage of using our eyes in physical settings is we can see a lot, as we get a lot of photons hitting our eyes. Our pixel-equivalent resolution standing in a library, bookshop or market is much more than we enjoy on our current screens. For most of us, moving our head feels far less effort than panning with a mouse, trackpad or touchscreen. Maybe virtual and augmented realities will redress that balance in the future, but right now ironically as we gain access to ever bigger and richer digital libraries, we frequently peek into the treasures therein through ever smaller windows. Sometimes there seems to be more room in the physical world than the virtual world. With falling costs of memory, processing power and bandwidth, there shouldn’t be - but at times it feels like there is. Virtually flying round vast virtual bookstacks just hasn’t taken off in the way that virtual reality pioneers in the 1990s might have expected. That may yet happen, but for now it can be informative to examine reasons why the real word has the edge in certain information seeking, especially browsing scenarios.

This is not to say that more focussed interactions with digital information interfaces don't have unique advantages. Nor that being embodied doesn't come with its own challenges in addition to opportunities afforded (Lueg 2014). For example, information has to be 'recognizable' and within range to be recognised i.e. body orientation and distance need to be 'just right'. Moving your head to quickly glance along a bookshelf may be easy, but tramping around a giant library can soon get tiring, plus you have the bother of getting to the library in the first place. Similar issues arise in thinking about our bodily interactions with the hardware of our digital devices. Smartphones may be light and portable, but a tiny screen can at times be hard work to view. A desktop display can afford more pixels, but too long sitting in the

same position leads to aches and back problems. Future giant displays with walls covered in thousands of pixels may make us realize that the world is a very large, very high resolution display. But gesture based interactions may cause arm ache – or maybe lead to a new kind of “interface pilates”. All design involves invidious trade-offs. Our aim here is to understand a bit more about different points in the design possibility space as our virtual and physical worlds become more explicitly intertwined. This intertwining happens through ubiquitous computing, involving many devices of various sizes enabling extended information based activities interleaved with other activities, Additionally, falling hardware, software, memory, processing and bandwidth costs enable more casual, ambient and frivolous information needs to be addressed.

EMBODIMENT AND INFORMATION NEEDS

Interestingly, it is not just information seeking that is affected by embodiment – it is also the generation of information needs (or problems) themselves. 'Information need' is another of information science's tricky concepts. Marchionini (1995, p. 36) postulated that “[r]egardless of the terminology used and the motivation, the information problem is the trigger for information seeking". However, just like knowledge, the information problem or need is never actually in hand, or as Belkin and Croft (1992) put it "[...] the information need is never ’observed’ since it is inside the people’s heads". This in turn leads to all kinds of conceptual and practical challenges (Lueg 2002) including the infamous frame-of-reference problem (Clancey 1991). Also see Hjørland (2007) for an insightful discussion of needs vs demands.

Just being in the physical world (walking around a street, an office, a market, a library, an apartment, etc.) can trigger, refine and even support the generation of new information needs. As Marchionini (ibid) also said "[the information problem] evolves and changes as the search and the overall situation evolve.” But is the nature of these the same? Or are they fundamentally different? Is what you want to find when you are wandering around with your smartphone (while being embedded in, and exposed to, an ever changing physical environment) different than when you are sat down with a laptop?

In looking at embodiment we need to consider a wider context of information interactions that can affect what people do, what they might want to do, how we can redesign our systems to improve things, and how we prioritize what to work on next. This includes our computer applications as software, the hardware devices that people use to interact with those applications, and the physical ways that people interact with those physical devices. It also includes the location where that interaction happens, the affordances and constraints it imposes on the interaction and how that can vary from context to context, how location and context has an impact in what people want to know and how they may be prepared to act to try and find things out. All that complexity should inform the design of our informational infrastructures and databases, and the degree to which they need to take all of the above into account in their organizational structure and supporting metadata.

DESIGNING FOR HUMANS NOT ROBOTS (OR VULCANS)

Designing for information use by embodied humans has various implications that we might consider blindingly obvious were it not for the fact that we at times seem to create information structures, algorithms, theories and interfaces that seem to ignore them. One implication is the way that our bodies affect our use of various information systems to meet our particular information needs at any given time. The other is how that same body and where it currently is and its accompanying context has some impact on the particular information needs we happen to have at any given time.

Considering the first, this leads to reminders that we are not patient, logical, rational robots. We are mammals who get tired, bored, exited, irritated, intrigued or distracted, and even change our minds about what we want to do (see e.g., Keilty 2012). We are wont to jump to conclusions and make fast decisions (Kahneman 2011) in ways that can serve us well in much of our lives but can be problematic in information seeking contexts that seem to have been designed to optimize careful deliberate practice.

Many interface and functionality designs already take aspects of these very human characteristics into account. Ranking algorithms help us to find the most likely relevant result when we can't be bothered to read to the end of the page, let alone click to get the next page of results. Certain systems and sets of systems may serve to distract us, such as a social media notification, and other options may be deliberately designed to help us protect ourselves from such distractions. A body needs to be aware of its wider environment to assess threats and risks, but those same evolutionarily advantageous adaptations can be deliberately or accidentally channelled into providing us with constant distractions and interruptions.

The act of digitization can separate a piece of information (say a paragraph in a book) from additional context that can be of great value to an embodied human. The heft of a book, the relative positioning of the page (roughly midway through the book), and of the paragraph on the page (near the bottom on the right), the cover, various marks of wear and tear, even the smell of the book, where we were standing when we held it, these and many more contextual cues can serve to help people in remembering, or in making the information salient. Again if we were robots these would be unnecessary epiphenomena. But we aren't so they are not. Such aspects of our embodied nature can help give clues as to why despite the many advantages of digitization, something is at times lost, particularly over support for browsing and serendipity.

The second point, that information needs are affected by embodiment, also needs to be considered. What we want to know changes depending on where we are, what we are doing and who is around us. Our bodies and the world that they inhabit create both constraints and opportunities to information needs. We are likely to want to know different things when we are sat at our desk at work, on the sofa at home, in a café, walking along a street, in a shop, on a bus, or when driving a car. As well as what we want to know changing, how we want it may change, depending on whether we want a good-enough answer, or the best available, or a quick easy to understand result. The applications we use are likely to vary with these use contexts, and be further constrained by our bodies. Sat at a comfortable desk, using a desktop PC we are likely to want different things and different access to the same information as when we are walking and using the much smaller screen of our smartphone, or cooking dinner and talking to our voice activated domestic device, or driving and giving (hopefully) most

of our attention to the traffic around us. Constraints of hardware, bandwidth, screen size, light levels, noise levels, attention, bodily postures, degree of privacy, et cetera all have an impact.

Sometimes we only become aware of the impact of our body on information seeking when some context creates a bodily limitation that becomes salient. That could be in contrasting typing on our comfortable ergonomic desktop PC keyboard with doing the same on our smartphone while standing in line at the supermarket checkout, or squinting at a tablet display in bright sunlight, or having to make rapid navigation decisions in a brief glance at our dashboard display in a complicated travel setting. The tendency to be only aware of the body at times of limitation or reduced capacity, including a temporary injury or progressive aging may be another reason for the relatively low attention given to the body in information seeking studies. Until, we might even speculate, that we aging researchers become all too aware of the impacts of our own bodies changing and those around them.

Additionally, context can provide affordances – memory triggers of things we were wanting to do, particular immediate information needs, interesting associations of ideas, explicit representations of subtasks so that we don't have to keep them all in our limited and fallible memories, new stimuli triggering whole new needs, etc. Indeed that can be one reason why we enjoy getting out and about, going to new places, visiting cities, wandering round markets. From a rational robotic logical perspective why go out shopping at all now we have Amazon?

Our propensity for distraction and desire for novelty, coupled with the inherent complexity of our lives can lead to information needs that keep on changing as we move through the world. Does this happen a lot? Do changing information needs matter? They are certainly remarkably inconvenient for doing studies (especially any kind of systematic controlled study) and writing papers about them. By contrast a single clear information need, and ideally one that we actually give to our subjects (a most telling term in this context) are so much easier to study, analyze and build theories around. Is that why we prefer to study tidy constrained information needs in a lab rather than messy changing ones as people wander around doing other things?

We can and do use things to serve as reminders and to manage goalstacks and interruptions. Messy desks, piles of papers, items set askew or in triggering places can all help us to supplement our thinking. These externalized distributed aspects of cognition that we discussed earlier are the counterpoint to various limitations of our reasoning ability such as limits to working memory, attentional bias, failing to see things in plain sight, habituation, recurrent reasoning errors etc. that psychologists have itemized and professional magicians have exploited for centuries (e.g., Kuhn et al., 2008). Interestingly, Kuhn et al. (2008) also demonstrate that while the magician manages to trick the 'mind', the perceptual system ('the eyes') isn't tricked. It's just that the mind 'overrides' the information that comes from the eyes just like at other times it prioritizes visual information over auditory information (Rosenblum 2010), all of which is part of the brain's quest to 'make sense' of a situation.

It can be a useful exercise to consider how our information retrieval systems might look if they were intentionally designed for robots, or indeed for Vulcans – the Star Trek species noted for its embrace of logic and suppression of emotion. Oftentimes

the result of such reflection is that tools intentionally designed for robots or Vulcans would look remarkably similar to tools we currently have. Then we can switch to consider how our information retrieval systems would looked if they were more intentionally designed for humans instead of robots or Vulcans. That exercise can lead to interesting and creative ideas about alternative interfaces and functionality.

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